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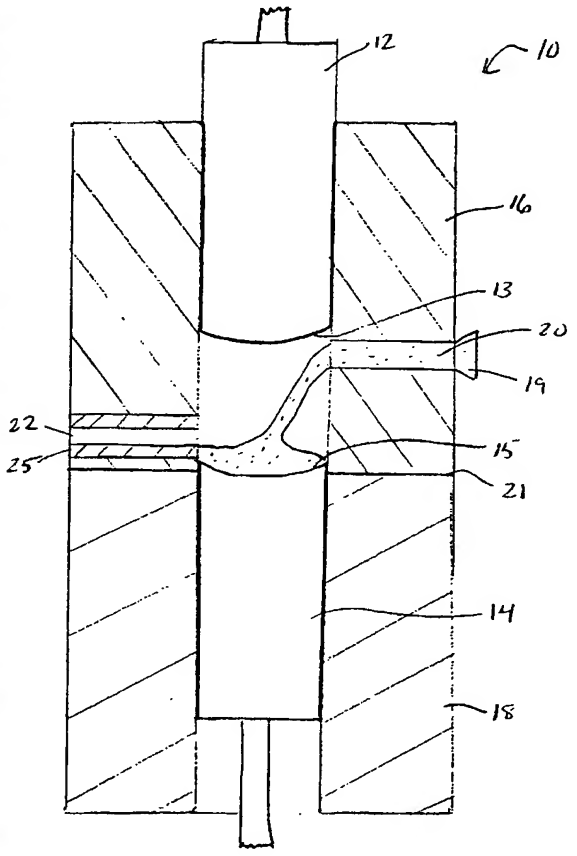
(54) Title: METHOD OF MOLDING LENSES



(57) Abstract: A method for directly molding lenses, especially contact lenses, provides a mechanism to remove excess lens material injected in the mold cavity and permits direct molding of a finished lens requiring no post-molding machining operations.

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For two-letter codes and other abbreviations, refer to the "Guidance Notes on Codes and Abbreviations" appearing at the beginning of each regular issue of the PCT Gazette.

METHOD OF MOLDING LENSES

Background of the Invention

This invention relates to a method for directly molding shaped articles such as ophthalmic lenses and/or biomedical devices. Representative articles are intraocular lenses and contact lenses. The method provides a mechanism to remove excess lens material injected in the mold cavity and permits direct molding of a finished lens requiring no post-molding machining operations.

A current method for molding contact lenses is cast molding, where a monomer mixture is charged between two mold sections, typically made of plastic, with one mold section having a molding surface shaped to form the anterior lens surface and the other mold section having a molding surface shaped to form the posterior lens surface; and then this mixture is cured between the mold sections. An example of such a method is described in US Patent No. 5,271,875 (Appleton). Typically, the plastic molds are first formed by injection molding, used to cast mold a single lens, and then discarded.

Prior to cast molding methods, various "direct molding" methods were known to mold a contact lens, i.e., the lens is cast in a permanent mold, made of a material such as glass or metal, rather than cast in "intermediate" plastic molds as in the aforementioned cast molding methods.

In both cast molding and direct molding processes, it is desired to mold a finished lens, i.e., a lens that does not require post-molding machining. It is also desired that the molding process is predictable and repeatable. This is complicated, however, since many lens material shrink upon curing.

Several processes of directly molding of lenses contemplate introducing into the mold cavity a precise, measured amount of lens-forming material. A problem with this approach is that it is difficult to control repeatedly the amount of lens-forming material introduced to the mold cavity, and if the amount of material is not precisely controlled, lenses having different dimensions may result. This is a particular problem with contact lenses since even slight variations in dimensions can affect optical properties or fitting characteristics of the lens.

Canadian application no. 2143901 describes a process for directly molding contact lenses where the apparatus includes an overflow reservoir to receive excess lens-forming material, the reservoir being located at the circumferential edge of the molding cavity. Since this reservoir is adjacent the molding cavity, it becomes necessary to ensure that the excess material in the reservoir is completely separated from the molded lens, otherwise the lens will have an uneven or rough edge. Ensuring such a "clean" separation between the molding cavity and the adjacent overflow reservoir becomes more complicated when using mold parts made of a non-deformable material, such as metal or glass.

This invention provides a method for directly molding lenses such as contact lenses that avoids the need to rely on introduction of a precise, measured amount of lens-forming material, and provides a mechanism to accommodate excess lens material introduced in the mold cavity while permitting molding of a finished lens.

Summary of the Invention

This invention provides a method of molding an ophthalmic lens in a mold comprising a first mold part and a second mold part. The first mold part has a molding surface shaped to provide a posterior lens surface and the second mold part has a second

molding surface shaped to provide an anterior lens surface, and the first and second mold parts are positioned in a mold block such that the first and second molding surfaces are opposed to one another. The method comprises the steps of: (a) introducing lens-forming material between the first and second molding surfaces; (b) moving the mold parts towards each other so that the lens material is compressed in a space between the first and second molding surfaces; (c) repositioning the mold parts in the mold block such that the space between the first and second mold sections is aligned with an outlet port in the mold block, whereby excess lens-forming material escapes into the outlet port; and (d) repositioning the mold parts in the mold block such that the space between the first and second molding surfaces is not aligned with the outlet port, and forming a lens between the molding surfaces of the repositioned mold parts. The invention also provides a method of molding a biomedical device in a mold and that comprises the aforementioned steps.

Brief Description of the Drawings

Figure 1 is a schematic cross-section view of an apparatus according to various embodiments, where the molding tools are in a position to receive lens-forming material.

Figure 2 is a schematic cross-section view of the apparatus of Figure 1, where the molding tools are positioned to compress the lens-forming material.

Figure 3 is a schematic cross-section view of the apparatus of Figure 1, where molding surfaces of the posterior and anterior molding tools are positioned in alignment with the outlet port.

Figure 4 is a schematic cross-section view of the apparatus of Figure 1, where the molding tools are positioned to mold a lens therebetween.

Figure 5 is a schematic cross-section view of the apparatus according to various alternate embodiments.

Detailed Description of Preferred Embodiments

Figure 1 illustrates an apparatus 10 according to various embodiments of this invention. The molding apparatus 10 includes a posterior molding tool 12 having a generally cylindrical shape and a molding surface 13 for forming the posterior surface of a lens. Anterior molding tool 14 has a generally cylindrical shape and a molding surface 15 for forming the anterior surface of a lens. The molding tools 12, 14 are received in bores of blocks 16, 18 separated by part line 21.

Lens-forming material 20 is introduced between molding surfaces 13, 15 via inlet port 19 which, in the illustrated embodiment, is formed in block 16. The lens-forming material is in a flowable state, and generally will be a liquid. For example, a nozzle of an injector may be received in inlet port 19, the nozzle injecting and dispensing the lens-forming material in the space between molding surfaces 13, 15. The apparatus also includes an outlet port 22 which, in the illustrated embodiment, is formed in block 18. Generally, an excess of the lens-forming material will be introduced between the molding tools at this stage.

During the introduction of the lens-forming material between the molding tools, tool 14 is positioned below outlet port 22, and tool 12 is positioned above inlet port 19.

The molding tool 12 is then moved towards molding tool 14 so that these tools assume the general configuration shown in Figure 2. In this configuration, both molding tools 12, 14 are positioned below outlet port 22. More specifically, molding tool 12 is moved towards molding tool 14 until a desired, predetermined position is obtained, with a compressive force being applied to the lens forming material in the mold cavity formed

between surfaces 13, 15. When the two molding tools are in this position, the spacing between the molding surfaces 13, 15 will generally be slightly larger than the ultimate mold cavity in the subsequent molding stage.

During this step in the process, the compression of the lens-forming mixture forces any gas in the cavity to escape. For example, the tolerance between the molding tools 12, 14 and the blocks 16, 18 is such that gas may escape but liquid lens-forming material will not be forced between the molding tools and the blocks.

Following this stage, both the anterior and posterior molding tools 12, 14 are repositioned to assume the general configuration shown in Figure 3. In this configuration, the cavity formed between molding surfaces 13, 15 is aligned with outlet port 22. Then, the molding tools are brought together until the molding surfaces 13, 15 have a predetermined, final spacing. During this stage, excess lens-forming material 20 is forced into the outlet port 22.

Then, both the molding tools 12, 14 are moved within the blocks 16, 18 to assume the general configuration shown in Figure 4. In this configuration, the molding cavity formed between surfaces 13, 15 is not aligned with either the inlet port or the outlet port. A compressive force is maintained while the lens-forming material is cured, to accommodate for shrinkage of the lens-forming material during curing. Heat can be applied by heating mechanism 25 to facilitate curing of the lens-forming material. If desired, the entire assembly can be placed under an inert environment, for example, in a nitrogen atmosphere, during curing.

Following curing of the lens-forming material, the posterior and anterior molding tools 12, 14 are separated and the lens is recovered. For example, the molding blocks may be separated along part line 21 to facilitate recovering the lens. Additionally, excess

lens material in the exit port 22 will generally be cured during curing of the lens-forming mixture in the cavity, and this excess material is removed. The cycle may then be repeated to form another lens.

Figure 5 illustrates an alternate embodiment where the apparatus is provided with an assembly 32 to assist in removal of excess cured lens material 31 from outlet port 22. In the illustrated configuration, assembly 32 includes a push-rod 33 that is received in a bore 34 in block 16, the bore 34 being aligned with outlet port 22. Thus, after the lens-forming material is cured to form contact lens 30, mold part 12 is retracted, and push-rod 33 is extended to push cured excess lens material 31 from port 22. Of course, prior to curing of the lens-forming material, push-rod 33 is retracted in bore 34.

Molding parts 12, 14 may be made of a rigid material such as metal or glass, with molding surfaces 13, 15 being an optically quality surface for forming the lens surfaces. Alternately, one or both of molding parts 12, 14 may be made of a plastic material. If the lens-forming material is photopolymerizable, radiation, such as UV radiation, can be directed to the mold cavity from radiation source 35, shown in Figure 5, in which case at least one of the posterior or anterior molding tools 12, 14 would be made of a radiation trasnmissive material. Alternately, polymerizing radiation may be directed to the cavity between surfaces 13, 15 by extending a fiber optic bundle through one of the mold parts 12, 14.

As previously mentioned, during curing of the lens-forming material, a compressive force is maintained to accommodate shrinkage of the lens material. The molding surfaces 13, 15 may ultimately come into contact with one another, at the edges of the molding surfaces, or these edges of the molding surfaces may remain displaced from one another. In the former case, the edge of the lens is formed between the

contacting edges of the molding surfaces; in the latter case, the edge of the lens is at least partially shaped by the bore walls of the block 16. When the molding surfaces come into contact with each other to form the lens edge, the mold parts may be made of materials with different hardnesses, so that the harder molding surface deforms the softer molding surface to facilitate the formation of a finished edge. In such a case, the softer mold part is preferably made of a plastic that is disposed after each molding cycle.

While the invention has been described with reference to preferred embodiments, it will be understood by those skilled in the art that various changes may be made and equivalents may be substituted for elements thereof without departing from the scope of the invention. For example, the molding surfaces of the molding tools may be shaped to form additional device features, such as haptics in the case of intraocular lenses. Therefore, the invention is not limited to the particular embodiments disclosed, but that the invention will include all embodiments falling within the scope and spirit of the appended claims.

I claim:

1. A method of molding an ophthalmic lens in a mold comprising a first mold part and a second mold part, the first mold part having a first molding surface shaped to provide a posterior lens surface and the second mold part having a second molding surface shaped to provide an anterior lens surface, and the first and second mold parts are positioned in a mold block such that the first and second molding surfaces are opposed to one another, said method comprising:

(a) introducing lens-forming material between the first and second molding surfaces;

(b) moving the mold parts towards each other so that the lens material is compressed in a space between the first and second molding surfaces;

(c) repositioning the mold parts in the mold block such that the space between the first and second mold sections is aligned with an outlet port in the mold block, whereby excess lens-forming material is received in the outlet port; and

(d) repositioning the mold parts in the mold block such that the space between the first and second molding surfaces is not aligned with the outlet port, and forming a lens between the molding surfaces of the repositioned mold parts.

2. The method of claim 1, wherein in step (a), the lens material is injected between the first and second molding surfaces.

3. The method of claim 1, wherein in step (b), the first mold part is moved towards the second mold part.

4. The method of claim 1, wherein step (c) includes positioning the first and second molding surfaces to a predetermined spacing while the space between these surfaces is aligned with the outlet port.

5. The method of claim 1, wherein step (d) includes heating the lens-forming material to cure the lens-forming material.

6. The method of claim 1, wherein step (d) includes exposing the lens-forming material to radiation to cure the lens-forming material.

7. The method of claim 1, further comprising separating the mold parts and recovering the lens.

8. The method of claim 1, wherein the lens is a contact lens.

9. A method of molding a biomedical device in a mold comprising a first mold part and a second mold part, the first mold part having a first molding surface and the second mold part having a second molding surface, and the first and second mold parts are positioned in a mold block such that the first and second molding surfaces are opposed to one another, said method comprising:

(a) introducing a device-forming material between the first and second molding surfaces;

(b) moving the mold parts towards each other so that said material is compressed in a space between the first and second molding surfaces;

(c) repositioning the mold parts in the mold block such that the space between the first and second mold sections is aligned with an outlet port in the mold block, whereby excess device-forming material is received in the outlet port; and

(d) repositioning the mold parts in the mold block such that the space between the first and second molding surfaces is not aligned with the outlet port, and forming a medical device between the molding surfaces of the repositioned mold parts.

10. The method of claim 9, wherein the device is a contact lens, and the first molding surface is shaped to provide a posterior lens surface and the second molding surface is shaped to provide an anterior lens surface.

Fig. 1

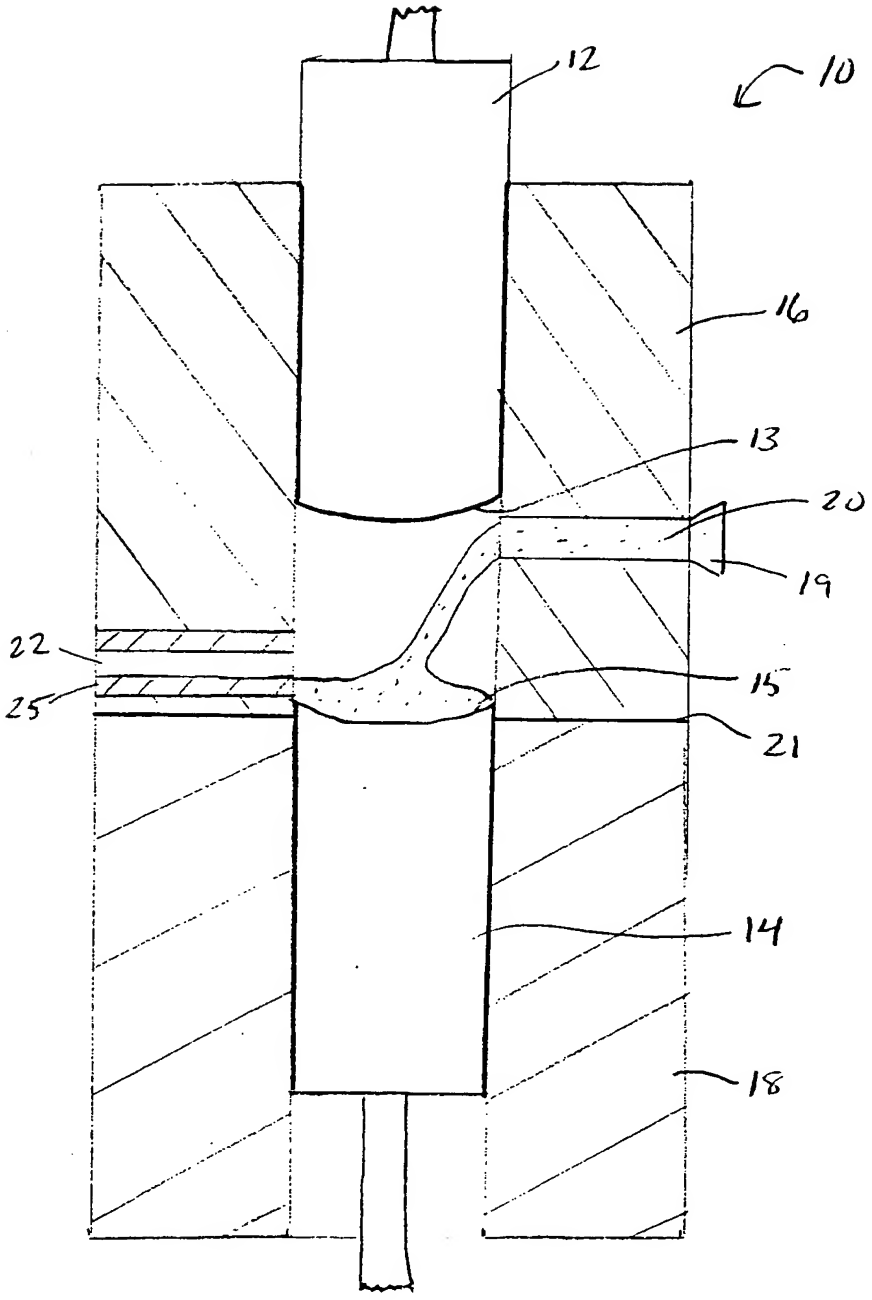


Fig. 2

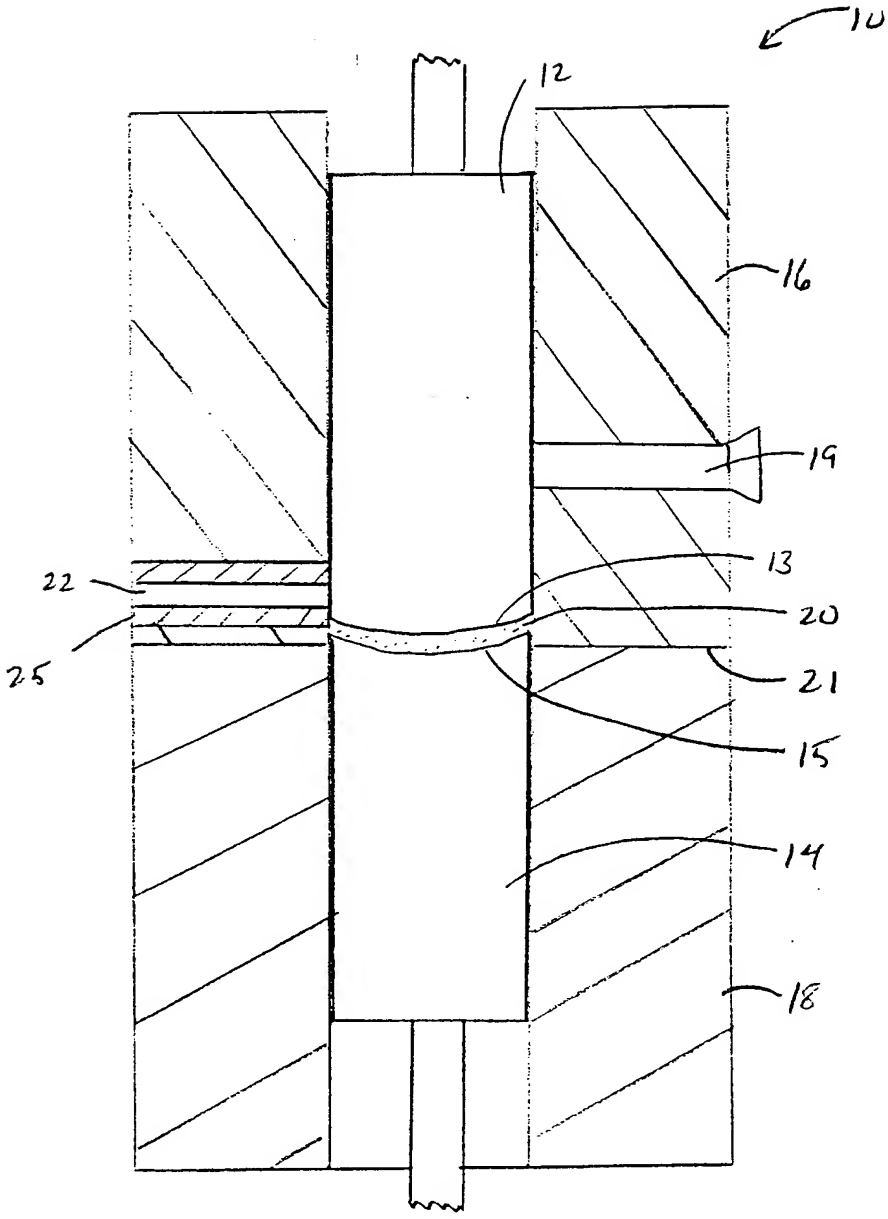


Fig 3

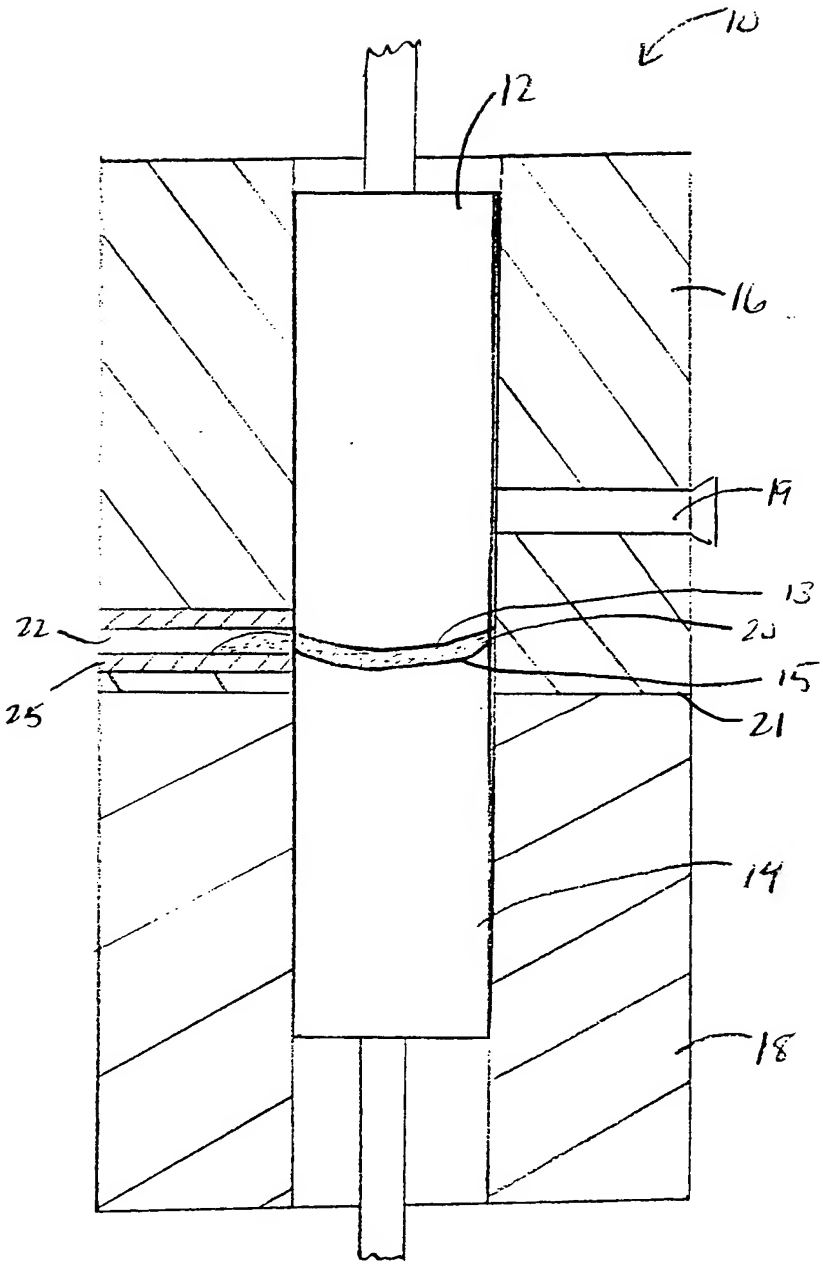
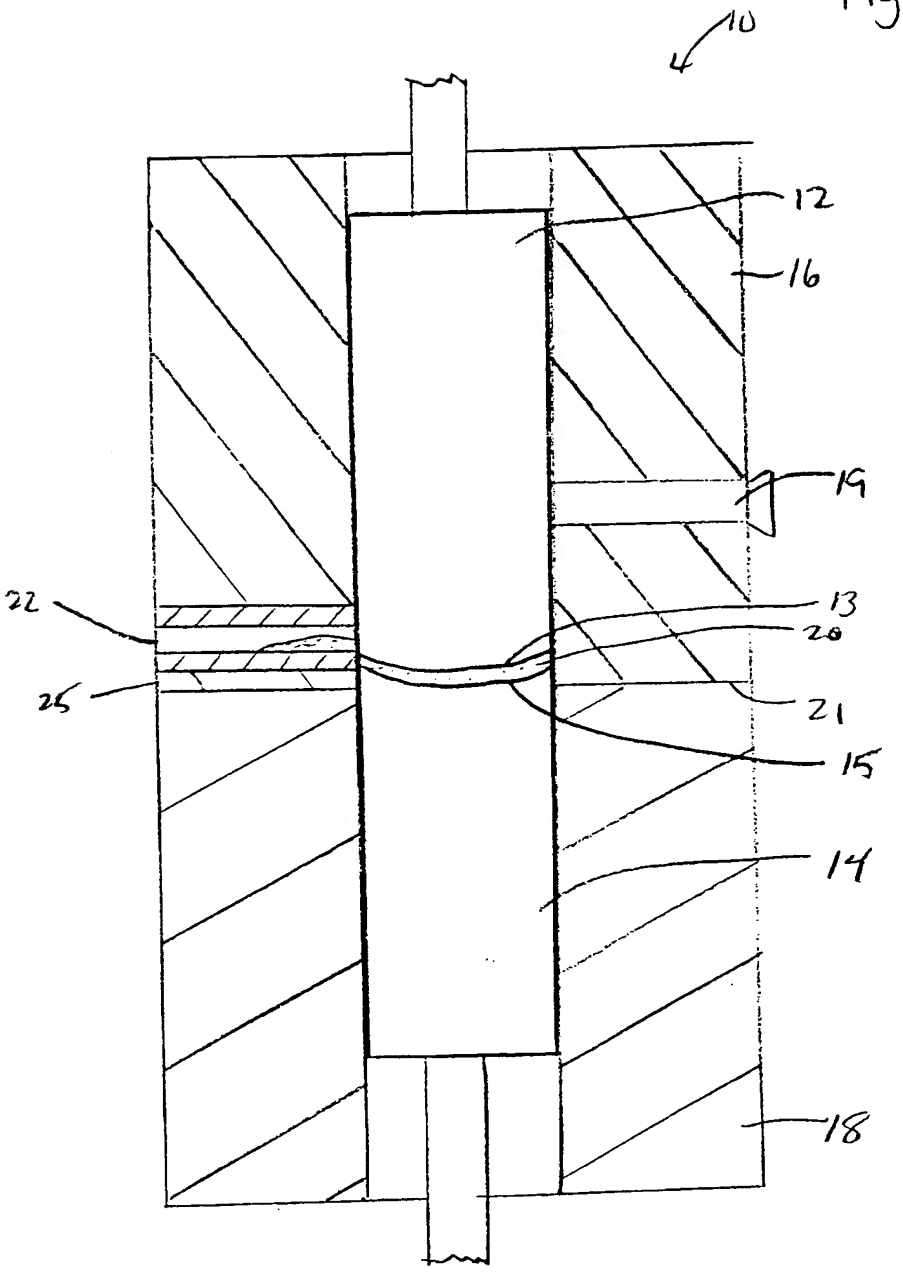
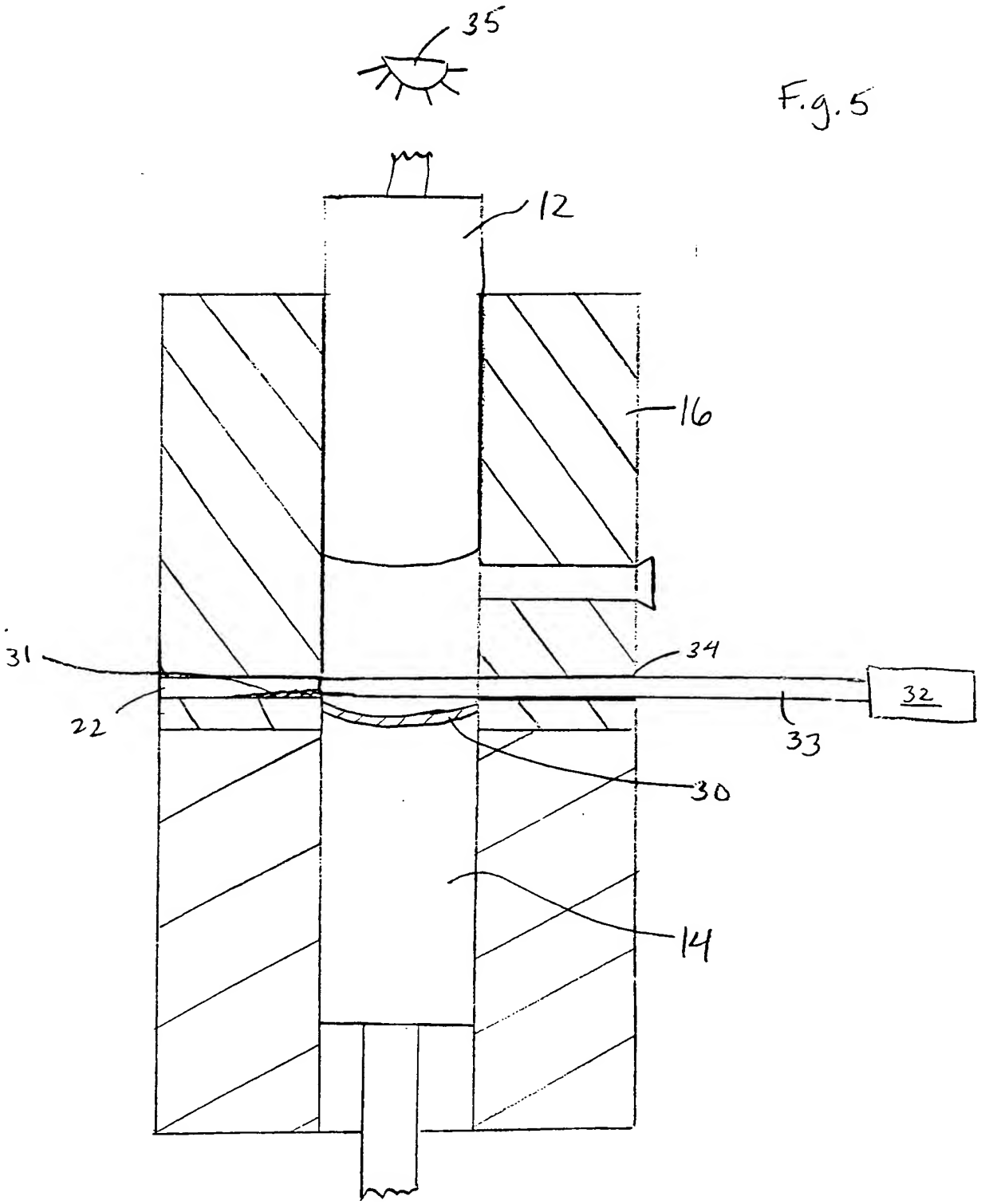


Fig. 4





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INTERNATIONAL SEARCH REPORT

Inter nal Application No
PCT/US 00/33585

A. CLASSIFICATION OF SUBJECT MATTER
IPC 7 B29D11/00

According to International Patent Classification (IPC) or to both national classification and IPC

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)
IPC 7 B29D

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched

Electronic data base consulted during the international search (name of data base and, where practical, search terms used)
PAJ, EPO-Internal

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category °	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X	US 3 005 234 A (ORIANI,CAPPELLI) 24 October 1961 (1961-10-24) column 3, line 50 -column 4, line 13; figures 6-8	1,3,4,7, 8
Y	FR 2 530 181 A (ESSILOR INT) 20 January 1984 (1984-01-20) page 12, line 2 - line 29; figures 2A-2C	1-4,7
Y	US 4 284 591 A (NEEFE CHARLES W) 18 August 1981 (1981-08-18) column 2, line 15 - line 31	1-4,7
A	GB 2 027 386 A (OMNITECH INC) 20 February 1980 (1980-02-20)	
A	WO 94 23929 A (SOLA GROUP LTD) 27 October 1994 (1994-10-27)	

☐ Further documents are listed in the continuation of box C.

☒ Patent family members are listed in annex.

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"A" document defining the general state of the art which is not considered to be of particular relevance

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Date of the actual completion of the international search	Date of mailing of the international search report
7 March 2001	16/03/2001

Name and mailing address of the ISA	Authorized officer
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INTERNATIONAL SEARCH REPORT

Information on patent family members

Interr ..al Application No
PCT/US 00/33585

Patent document cited in search report	Publication date	Patent family member(s)	Publication date
US 3005234 A	24-10-1961	NONE	
FR 2530181 A	20-01-1984	JP 1667597 C	29-05-1992
		JP 3024328 B	03-04-1991
		JP 59026221 A	10-02-1984
		US 4569807 A	11-02-1986
US 4284591 A	18-08-1981	NONE	
GB 2027386 A	20-02-1980	AU 524955 B	14-10-1982
		AU 4902379 A	14-02-1980
		BE 878148 A	03-12-1979
		CA 1124469 A	01-06-1982
		DE 2932499 A	28-02-1980
		FR 2432929 A	07-03-1980
		JP 1405129 C	09-10-1987
		JP 55027300 A	27-02-1980
		JP 62012019 B	16-03-1987
		NL 7905618 A,B,	12-02-1980
		US 4364878 A	21-12-1982
WO 9423929 A	27-10-1994	US 5405557 A	11-04-1995
		AU 678006 B	15-05-1997
		AU 6559494 A	08-11-1994
		AU 678578 B	05-06-1997
		AU 6706694 A	08-11-1994
		DE 69411721 D	20-08-1998
		DE 69411721 T	15-04-1999
		DE 69411728 D	20-08-1998
		DE 69411728 T	18-03-1999
		EP 0696955 A	21-02-1996
		EP 0695231 A	07-02-1996
		WO 9423928 A	27-10-1994
		US 5523030 A	04-06-1996